Faculty of Mechanical Engineering

TWO STROKE SWIVEL MOTION ENGINE SIMULATION USING LOTUS ENGINE SOFTWARE

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TWO STROKE SWIVEL MOTION ENGINE SIMULATION USING LOTUS ENGINE SOFTWARE

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A Master Project Report submitted
in fulfillment of the requirements for the degree ofMaster of Mechanical Engineering (Energy Engineering)

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DECLARATION

I declare that this report entitled "Two Stroke Swivel Motion Engine Simulation Using Lotus Engine Software" is the result of my own research except as cited in the references. The research has not been accepted for any master and is not concurrently submitted in candidature of any other master.

Signature : .....

Name : Alifh Omar Bin Amir

Date : 16/05/2016

APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality as a partial fulfillment of Master of Mechanical Engineering (Energy Engineering).

Signature : .....

Supervisor Dr. Shamsul Anuar Bin Shamsudin

Date : 17/05/2016

DEDICATION

To my beloved mother and father,

My beautiful wife, Norizan and our playful kids, Zahra, Safiyyah and Aisha.

You all made everything worthwhile.

My greatest respect for Dr Shamsul Anuar Shamsudin.

ABSTRACT

A study was carried out to simulate the two-stroke swivel motion engine configuration using *Lotus Engine Software (LES)*. The *LES* is one of the popular engine simulation packages besides *Ricardo Wave (RW), GT-Power* and *AVL fire*. The *LES* was built as a key part in the automotive development process developed by *Lotus Group*. The two-stroke swivel motion engine is a novel design engine. This study was done by simulating one cylinder engine and two cylinder engine. The result is compared with previous study that has been done by *GT-Power* simulator.The study suggests both software shown similar output trend in brake power and torque. However, *LES* has shown a better result in *BSFC*.

ABSTRAK

Satu kajian telah dijalankan bagi simulasi ke atas enjin 2 lejang gerakan swivel menggunakan Lotus Engine Software (LES). LES adalah salah satu pakej simulasi enjin yang popular selain Ricardo Wave (RW), GT-Power dan AVL Fire. LES dibina bagi menjadikan ia salah satu komponen proses pembangunan automotif yang telah dibina oleh Lotus Group. Enjin 2 lejang gerakan swivel adalah rekaan engine yang novel. Kajian ini telah dijalankan ke atas enjin 1 silinder dan enjin 2 silinder. Hasil penelitian dibandingkan dengan kajian terdahulu yang telah menggunakan perisian GT-Power. Kajian mencadangkan kedua-dua perisian menunjukkan aliran output yang sama dalam kuasa brek dan tork. Walau bagaimanapun, LES telah menunjukan keputusan BSFC yang lebih baik berbanding GT-Power.

ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my sincere acknowledgement to my supervisor Dr. ShamsulAnuar bin Shamsudin from the Faculty of Mechanical Engineering,*UniversitiTeknikal Malaysia Melaka* (UTeM) for his essential supervision, support and encouragement towards the completion of this research.

I would like to thank Majlis Amanah Rakyat.

Special thanks to beloved mother, father, wife, children and friends for their moralsupport in completing this project. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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T	-	Torque
W	-	Known radius
R	-	Axis of rotation
bp	-	brake power
N	-	Number of cycles per unit time
P	-	Pressure
m_f	-	Mass flow-rate
BSFC	-	Brake Specific Fuel Consumption
n_V	-	Volumetric efficiency
V	-	Volume
LES	-	Lotus Engine Simulation Software

LIST OF APPENDICES

CHAPTER 1

OVERVIEW

Commercial engine simulation package generate detailed estimation of engine performance. Two-stroke swivel motion engine has been studied by Shamsudin (2004a) to understand the performance of a novel swivel-motion engine design. This swivel-motion engine design shown a good performance in term of power and torque output. The research was done using *GT-Power*, a commercial code for engine simulation. In this study, simulation packages, *LotusEngine Simulation* will be used to test the swivel motion engine. The results will be compared to the result obtained by Shamsudin (2004b). This study is also planned to study the swivel-motion engine with two cylinders.

1.1 Objectives

The purpose of the research is:

a. to study *Lotus Engine Simulation* software on swivel-motion engine;

b. to compare the *LES* results with *GT-Power* results;

c. to study the engine with two cylinders and suggest several improvements.

1.2 Scope of the project

Swivel motion engine is an interesting novel design of engine which need to be tested. There are several simulation software in the industry and comparison of engine simulation software are needed to give a better view of the engine and to verify the results given by the each software. The engine configuration is tested to obtain the following.

a. The engine output (Brake power and Torque)

b. Fuel consumption parameter (Brake Specific Fuel Consumption)

c. Other useful engine performance parameters.

1.3 Report Organization

The rest of the report is organized in the following manner. Chapter 2 reviews some of the works done previously in the simulation of engines particularly the work by Shamsudin (2004) using GT-Power as the analysis tool. Next, the procedures of research taken in this study are laid out in Chapter 3. Following this, the results from the analysis are presented and discussed in Chapter 4. Lastly, the conclusions and some recommendations are covered in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 ENGINE CONCEPT

Credits should be given to Sulaiman and Surdiman Zahuri (2004) as cited in Shamsul Anuar (2004) for designing the concept of two stroke swivel engine. This engine utilize certain enhancements such as direct gasoline fuel injection system, supercharged air intake, and typical lubrication system similar to the four stroke engine. This engine mechanisms is utilising a tilted compound bevel gear mechanism in place with crankshaft slider-crank mechanism. The studied engine is detailed out in Figures 2.1 through 2.5.

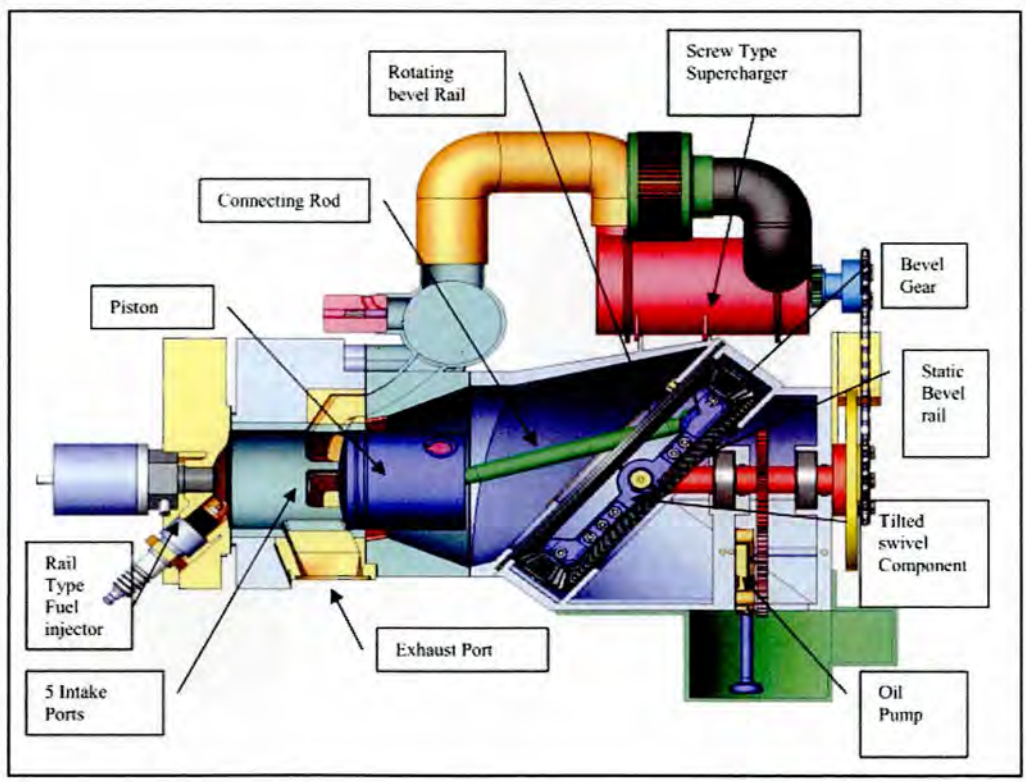

Figure 2.1: Cross-section of swivel motion engine from Shamsudin (2004)

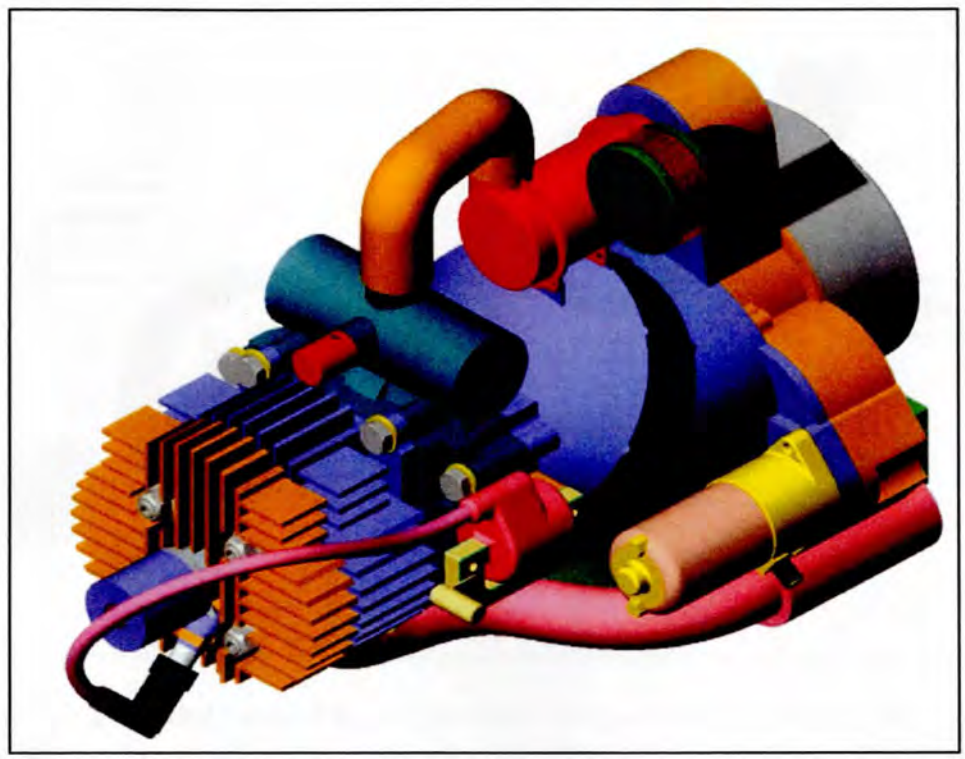

Figure 2.2: Two stroke swivel engine. Copied from Shamsudin (2004).

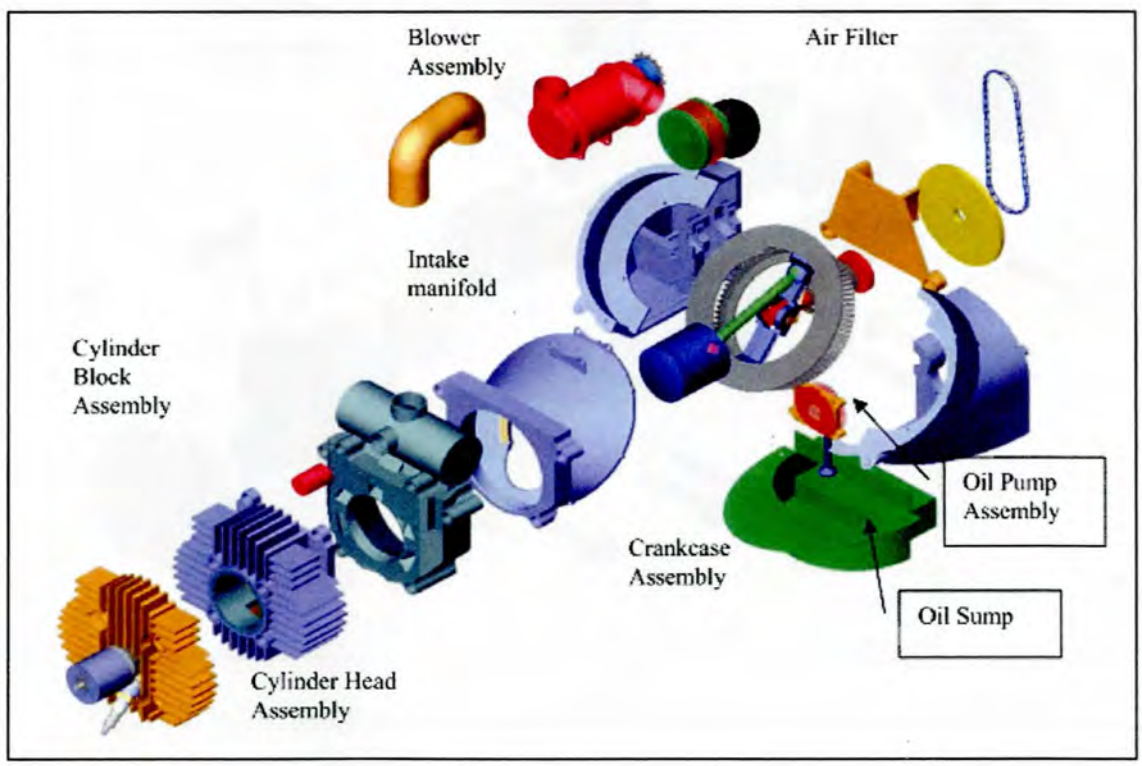

Figure 2.3: Exploded view of the two stroke swivel engine from Shamsudin (2004).

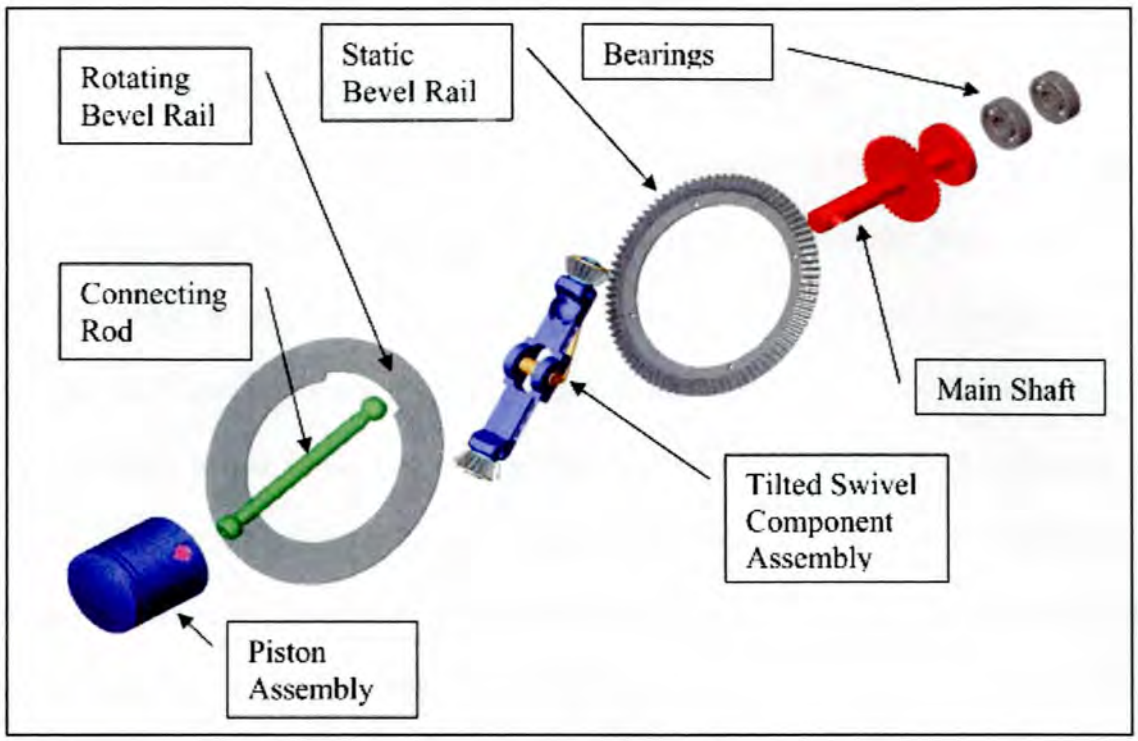

Figure 2.4: Exploded view of the engine inner components from Shamsudin (2004).

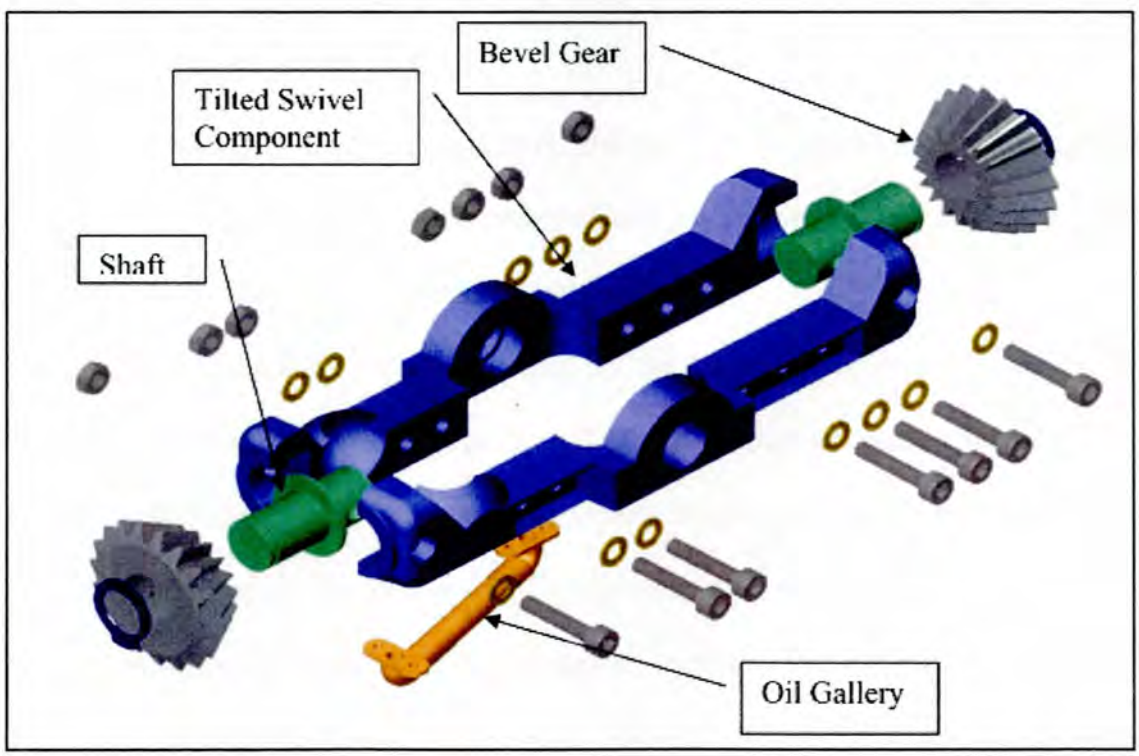

Figure 2.5: The tilted swivel component assembly from Shamsudin (2004).

2.2 COMMERCIAL ENGINE SIMULATION SOFTWARE

Kin Yip Chin et al. (2013) review on engine simulation software for control system development. Their study utilize several commercial codes, Ricardo Wave and Lotus Engine Simulation and one in-house developed package. Lotus Engine Simulation was developed by Lotus Engineering which process in two module, which is data module and solver module, as per Lotus Engineering Simulation user's manual (2011). Meanwhile, Ricardo-Wave is an engine simulation package that can be used to analyze the dynamics of pressure waves, mass flows and energy loses. It is a time-dependent fluid dynamics and thermodynamics using two-zone model.

Branislav Duleba (2014) stated four commonly used engine simulation package are Ricardo Wave (RW), Lotus Engine Simulation (LESoft), GT-Power and AVL fire. The packages are quite similar where input parameters are used to simulate engine operation in an integrated manner.

AVL CRUISE is a vehicle simulation and powertrain analysis that was designed to develop and optimize low emission engines, reliable powertrains, and sophisticated control systems of engines, cooling, and transmission systems.

Gamma Technologies (2009) focuses on the transportation engine industry. The main product, GT-SUITE offers several vehicle and engine technical applications that include engine performance simulation and vehicle dynamics analysis. It has a versatile multiphysics platform to model a variety of engineering problems through a combination of the acoustics, flow,thermal, electric, mechanical, chemistry and controls.

Yang Bai (2013) found that the main benefits of engine commercial simulation software is their ability to handle a range of engine and vehicular applications. The availablestate-of-the art graphic user interface or GUI and modelling methods allow users

to predictthe engine performance using drag-and-drop of icons from its element library. It includes accurate engine performance block and engine component blocks, dynamic control blocks for real-time simulation. The software also incorporate vehicle dynamics blocks that make it possible to analyse engine emissions and combustion. This simulation software assists car designers in making the right decisions which leads to competitive advancements in term of emissions,fuel efficiencyperformance, and drivability.

2.3 CUSTOM SIMULATION PACKAGE

Some simulation softwares can be developed using writing source code in the program to run the functions which are using programming language such as C++, VB, VF, Fortran, etc. Programs such as MATLAB, Dymola and Modelica are specially designed for mathematical operations and data processing. Expertise in various subjects is needed in the source code writing.

Yang Bai (2013) states two advantages of using custom simulation packages.The first advantage is it overcome the limitation in commercial codes for novel engine design analysis as the commercial software is specially design for automotive engineering only whereas the real automotive engine design developments need various and wide range of engineering knowledge. The second advantage is custom simulation package user can customize the blocks for developing and optimizing engine block where commercial codes only have predefined block parameters.However, building the custom simulation package model is very difficult and time consuming.

2.4 MODEL BUILDING AND SIMULATION

Duleba (2013) model building was done in Lotus Combustion Chamber tool and the first phase of the model building work was to define the combustion chamber. Boxer type engine was defined for the model. Here, 300 parameters were defined such as length and type of intake pipes, diameter of throttle body, type and complete map of supercharger, shape and diameter of exhaust, heat transfer model, scavenging model, material types to friction analysis tool. The simulation was set to calculate only 7 exact values of RPMs (1000-7000, step by 1000). Figure 2.6 displays a snapshot of Duleba's work.

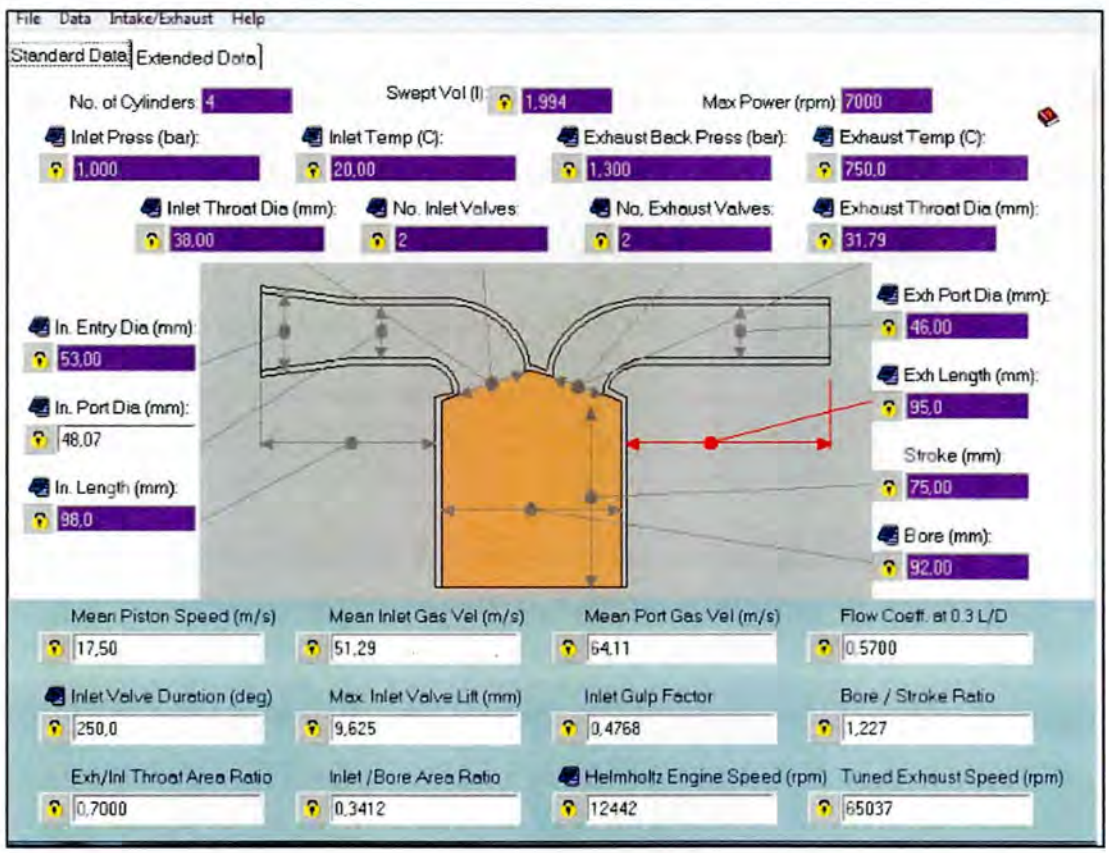

Figure 2.6: Lotus Engine Software Chamber Toolby Duleba (2014)

By using Lotus Engine Software, main input file are read by the solver during simulation. This main input files contains the model network, initial conditions for the flow